

# Special issue Research

# TPM QUARTERLY

## TPM research leads the way internationally

Theo Toonen, Hans de Bruijn

**The TBM faculty achieved extremely high scores in the external research assessment for the period 2003-2009. It scored an average of 4.5 on a five-point scale. TPM's largest programme, Next Generation Infrastructures, even achieved four scores of 5 out of 5. Philosophy of Technology Design and Values came a close second. This means that TPM enjoys a leading position at the pinnacle of international science. The external assessment also involved an assessment of TU Eindhoven and the University of Twente. Two of the three best-scoring research groups were at TU Delft.**

'Am I working on the right areas and doing it well?' In order to safeguard the quality of the research programmes, TU Delft, TU Eindhoven and the University of Twente arrange for an external assessment once every six years (and an internal audit every three years). The assessment is conducted by a committee of external academics, who make up the organisation Quality Assurance Netherlands Universities (QANU). The review committee for 2003 - 2009 included Prof. Arthur Ringeling, Erasmus University Rotterdam (chair); Prof. Gunnar Eliasson, Kungl Tekniska Högskolan, Stockholm; Prof. Kingsley E. Haynes, George Mason University, USA; Prof. Michael Howlett, Simon Fraser University, Canada; Prof. Deborah G. Johnson, University of Virginia, USA; Prof. Stefan Klein, Westfälische Wilhelms-Universität, Germany and Prof. Nico Vandaele, Catholic University Leuven-Kortrijk, Belgium.

### World leaders

The five TPM research programmes Innovation Systems, Multi-Actor Systems, Next Generation Infrastructures, Risk & Design, and Philosophy of Technology, Design and Values were all inspected in terms of quality, performance, social relevance and potential for growth. The results of the research assessment

by QANU are featured in the accompanying boxes. The best performing group was Next Generation Infrastructures, led by professors Margot Weijnen and Ernst ten Heuvelhof, with a maximum score of five for all components. This performance places the group among the world leaders: 'We have never before seen such an impressive research programme in terms of quality, productivity and scope' said the committee's report.

TPM Dean Theo Toonen and TPM Director of Research Hans de Bruijn are satisfied with the performance achieved. Toonen: "The faculty did outstandingly across the board. As well as productivity and quality, all groups were praised for their well-organised approach to research, the originality of their ideas and their contacts with wider society. The high level of external funding was also appreciated: more than half of our faculty is funded by external sources. The committee also wrote that, amid all the cutbacks, it had discovered 'an extremely self-assured faculty'. They found an academic staff who are convinced that 'the future is shaped here'. And clearly this is also something we project to the outside world. We are very proud of that. We have a good idea of what it is we want."

### Building on the factors of success

But both De Bruijn and Toonen stress that the excellent results should not be seen as a reason for resting on one's laurels. "We are on the right track, but we still have some way to go. For example, the Risk and Design and Innovation Systems groups received a positive assessment, but the committee did feel that they are lagging slightly behind in terms of viability and their links with the faculty's research programme as a whole. We will need to translate the success of NGI into real European research funding, in alliance with the business community, social partners and government bodies. Philosophy and Ethics have been successful in securing indirect funding and because of that alone they must be provided with more structural funding within the university context. We therefore need to continue to focus on the future, on new developments and potential. One way of achieving this is by building on the current factors of our success. In other words,

focusing even more on scientifically innovative approaches, on tackling real-life problems and on internal and external cooperation."

One way in which TPM innovates is by continually identifying new areas of application. Examples of these include gaming and simulation and value-sensitive design. De Bruijn: "The strength of TPM lies in the fact that engineers and social scientists work closely together. They understand and challenge each other and achieve things by means of effective cooperation. Issues within society are becoming increasingly more complicated because of their technical, administrative, political and social connotations." Toonen: "At TPM, engineers and experts in policy have discovered a shared vocabulary. This is a policy we will definitely continue."

The Dean adds: "The same applies to our approach to realistic world problems. We do not conduct research for its own sake, but, as befits a faculty at an engineering university, we actually tackle genuine existing social and administrative issues. This approach is partly responsible for our current success and is something supported by the review committee. We bring the living laboratory into the practical world and make an impact at a high level, right up to the boardrooms of leading companies and policymakers." De Bruijn: "We seek out challenges in real-life issues, because this helps us to continually innovate. Rapid developments in the world provide us with lots of impulses and our critical mass enables us to take on a wide variety of issues. Over the last eight years, this has made us into a breeding ground for new initiatives, such as gaming and simulation, but also for the continued development of work that transcends and blends different disciplines and the exploration of new areas through the systematic combination of engineering and technology with ethics, governance and institutional issues. This is a role that we are determined to expand even further."

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## TPM research leads the way internationally

At the end of 2010, the world - including the Netherlands - was given an object lesson in public administration by Julian Assange. Or more precisely, in *Systems Engineering, Policy Analysis and Management*: he demonstrated how technology and ICT can influence and change relationships in public administration, how global politics is becoming transparent, and how far the act of sharing and accessing information can actually go. Citizens looked on and licked their lips: that was the novelty factor. But the content of the American diplomatic telegrams, or cables, is actually old news. Civil servants and politicians have always formed coalitions against other civil servants and politicians. In the jargon, the process is known as compartmentalisation. More popularly, it is referred to as interdepartmental tribalism. It happens in the Netherlands and at a European level. Ministers and their civil servants in particular sectors - economics, water or finance - often take on their national counterparts responsible for, say, the environment, public health or social affairs. And this happens on the world stage as well. The phenomenon is known as bureaucratic infighting or factionalism and is a familiar theme for experts in public administration. But now, thanks to Wikileaks, it is also familiar to the man on the street: a classic issue in public administration has become part of a wider plot featuring sex, drugs and rock and roll. Social networks fade in comparison.

Last week, I dined with the vice president of TU Delft. Some would consider that to be consorting with the enemy. It is a small-scale version of this wider phenomenon. If I were to write a cable on my meeting, it would read as follows. The subject of the discussion was the research inspection recently conducted at TPM. According to the final assessment of the inspection, the research in our faculty is of international calibre. Personally, I believe that any future research inspections should not be limited to the context of 3-TU. We are ready to take on international benchmarks. We will join forces with our international partners in the competition against others in the Netherlands. But leaving that aside for the moment - what matters is that when he arrived, Karel Luyben was quick to spontaneously compliment TPM. He found it simply fantastic that such a mixed, multidisciplinary group of scientists and academics, almost thrown together just ten years ago, had succeeded in developing such a coherent and well-defined programme, with such a high impact. 'So what does that mean for us as a faculty?' I asked him. There was a moment of silence. Those of us involved in administrative factionalism know only too well that this kind of research assessment does not necessarily mean additional funding. The real gains come in terms of credibility, confidence and psychological credit. Indirectly, it will mean that we will have easier access to funding from the NWO, European funds and hopefully also from businesses. But that does not mean that we should now imagine we can move forward as outstanding research groups on our own. On the contrary: the secret of TPM's success - interdisciplinary cooperation and the building of internal bridges in order to perform externally - is something that we must continue to develop and bring to fruition over the next ten years. We need to make a name for ourselves internationally. Within TU Delft, partly thanks to this assessment, we are a significant factor in the strategic choices that need to be made. That is what this positive assessment will bring: this much the vice-president was willing to confirm. And I don't mind leaking as much to you now.

Prof. Theo Toonen, Dean

### Joining forces

Cooperation is and remains the basis for TPM's success. Toonen: "In recent years at TPM, we have worked to reinforce institutional relationships and cooperation at programme level. The external assessment shows that we have succeeded in making TPM into an integrated whole. Externally, we have developed strong contacts with Bangalore, Harbin, Queensland, Tokyo and Singapore and forged alliances with a range of different universities across Asia. We will continue to pursue this route in the years to come. We will be happy to continue regional developments by collaborating with the universities of Rotterdam and Leiden, but will also expand our relationships with institutions in Europe, the Americas and Asia. In order to achieve that, we will need to join forces more effectively internally. For example, from its international perspective, the review committee observed that the economics and innovation research area could become more strongly involved in other ongoing work at TU Delft and strengthen its relationship with infrastructural research in particular."

The assessment committee also approved TPM's strategic plans in the context of the TU Delft review. Toonen: "So this is something we can continue. In addition, we also aim to underline our ambitions to become a permanent player in the international world. We must and want to become more of a global player, starting by further strengthening and communicating TPM's body of knowledge in the Netherlands and in Europe. The following external research assessment, in five to six years, will take the form of a benchmark with international peers. Other key areas of focus include the continuity of our funding, third-generation researchers (those in their thirties aspiring to a senior position) and the consolidation of a number of newly developed areas of study that have been validated by the committee, including the economics of infrastructures, serious gaming and productivity research in relation to technological innovation. We will put all our efforts into achieving these things."

This list of ambitions should also include the Graduate School. This is a university initiative that is expected to be formally launched in September and which can further support and strengthen the developments envisaged for TPM. The aim of the Graduate School will be to improve the supervision provided for PhD programmes. This is necessary because a number of PhD candidates fall by the wayside and drop out after a few years, or take too long to complete their PhD programme according to a range of different measures. This results in an enormous loss of capital, which is preventable. "We aim to further professionalise the PhD education we offer. Talented PhD students from the Netherlands and abroad must be able to come here and deliver a quality thesis at an acceptable pace and with excellent supervision."

### Beautiful swan

Toonen and De Bruijn look to the future with confidence. "If you are successful, you also attract successful people. It leads to a snowball effect. As the QANU committee said in its opening statement: 'All three of the inspected faculties have developed from 'Ugly Ducks' into 'Beautiful Swans'.

All three technical universities are encountering problems associated with a reduced interest in technical education.

Despite this, the faculties are stable or growing, even in terms of the numbers of students. They are an exception to the rule. The image of the inspected faculties within the technical universities has been transformed from that of an ugly duckling (read: non-technical, as compared to the exact sciences) into that of a beautiful swan. There is no doubt that this will have a snowball effect."



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**Prof. Kingsley Haynes, George Mason University:**  
"You have developed an outstanding set of research groups all of whom are at or well above international standards and in some cases are positive outliers in setting new levels of research focus and impact world wide. I do not say this easily as I have been involved in national and international reviews and comparisons for 30yrs. I have never seen a consistently high level across all fields offered as has been indicated in this program at Delft. Your faculty and students deserve clear recognition for the high research standards they have achieved and the new standards they are setting across the professional academy. I was truly impressed!"

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### Ranking of TPM/TU Delft research groups

- 1. Next Generation Infrastructures** led by professors Margot Weijnen and Ernst ten Heuvelhof, score: 5
- 2. Philosophy of Technology, Design and Values** led by professors Peter Kroes, Jeroen van den Hoven and Dr M. Franssen, score: 4.8
- 3. Multi-actor systems** led by professor Wil Thissen, score: 4.5
- 4. Innovation Systems** led by professor Alfred Kleinknecht, score: 4.025
- 5. Risk & Design** led by professor Ben Ale, score: 4

### Top 3 Research Groups at Delft, Eindhoven and Twente

As well as TU Delft's TPM faculty, the external research assessment also reviewed Industrial Engineering & Innovation Sciences at TU Eindhoven and Management and Governance at the University of Twente. At the three universities, a total of 17 research groups were reviewed. The best-scoring programmes were:

- 1. Next Generation Infrastructures**, TPM/TU Delft
- 2. Modern Societies in Transition**, TU Eindhoven
- 3. Philosophy of Technology, Design and Values**, TPM/TU Delft

TU Delft achieved an average score of 4.5 on a five-point scale. TU Eindhoven scored 4.2 and the University of Twente averaged 3.6.

### Pleased to make your acquaintance: QANU

Quality Assurance Netherlands Universities (QANU) conducts external assessments of academic education and research at universities. It also provides recommendations for improving internal quality assurance. According to the QANU website, the word qanu (pronounced: kanu) originates from the Akkadian language and is related to the Sumerian word Gi which means reed, yardstick or measure. The English word cane originates from this as does the word canon, via Latin and Greek.

# Breaking down all the barriers



Margot Weijnen

**In recent years, TPM's research programme Next Generation Infrastructures (NGInfra) has earned itself a solid international reputation as a breeding ground for innovative**

**research on infrastructure. In many respects, NGInfra is a rather unorthodox programme. This places some pressure on a review committee which is tasked with providing an overall assessment of substantive quality and performance. In addition, the results send out an important message to the outside world. The programme received an excellent assessment in all criteria. Programme leader Margot Weijnen: "Although I am not surprised, I do feel honoured by the many compliments we received from the committee. This assessment confirms our belief in the enormous potential of research into infrastructure systems."**

So why is it unorthodox? Weijnen, Professor of Process and EnergySystems: "For a start, its size is unusual for an academic research programme: almost 55 FTEs in 2009, more than 40% of TPM's total research capacity. This makes it by far the largest programme that the review committee inspected. But much more importantly, I know of no other research programme that covers so many different disciplines and sectors at the same time. Our programme straddles a wide range of infrastructure systems across different sectors: energy, transport, water, IT and telecom. When other research centres look beyond the boundaries of infrastructural sectors, they generally do so from a specific discipline-based perspective. Equally, there are many research centres that conduct interdisciplinary infrastructural research like we do, but in that case they limit themselves to a specific infrastructural sector. And in addition to our interdisciplinary and intersectoral ambitions, we have also invested enormous energy in internationalising our programme and collaborating with those who use the knowledge."

During the previous external assessment in 2003, Next Generation Infrastructures was not yet in existence. At that stage, research into infrastructural systems was still in an exploratory phase. A national research grant of € 20 million made it possible to establish NGInfra on a wider scale. It was able to grow quickly into a leading programme of international standing with a solid scientific basis. Every year, its productivity and impact grew in leaps and bounds. While increasing numbers of universities in the Netherlands and beyond became associated with the subject, TPM remained and still remains the biggest player and the driving force in Next Generation Infrastructures. Ernst (ten Heuvelhof, joint programme leader) and I are full of praise for the work of the subsidiary programme leaders. They deserve the greatest of compliments. Ernst and I have given them the space they need to develop their own ideas and they have all seized the opportunity to establish a powerful and innovative subsidiary programme that clearly carries their personal stamp", says Weijnen, full of appreciation.

One of the areas with which the review committee was particularly impressed was the effective cooperation between researchers and users, which has resulted in an excellent balance between academic value and practical usefulness. The broad, interdisciplinary and intersectoral research area was greatly appreciated, as was the intensive international cooperation. Weijnen: "We have high expectations for the cooperative agreements that we have entered into with CSTEP, an independent think tank in Bangalore, India, and with a number of other parties in Shenzhen, China. Of course, India and China are fascinating. Both countries are rapidly developing their infrastructure on a scale unthinkable within Europe. For us, it is extremely exciting to investigate the extent to which concepts and research results are of use in the cultural and institutional context of India and China." An important Dutch example is 'Maasvlakte2', which is being developed in cooperation with the Rotterdam port authority.

Weijnen: "Academic research is all about breaking down boundaries. Breaking down the boundaries of disciplines and sectors does not make life any easier, but it does make it more exciting. The fact that we also transcend the borders of countries and continents is inevitable because physical infrastructure networks also do that. In an institutionally fragmented international setting, how do we ensure that we are guiding the development of these large-scale systems in the right direction for society? How do we ensure that the infrastructures we construct today will still be effective for economic development in the decades to come? In order to answer questions like these, we need knowledge of the technology in which we would need to invest, and understanding of the interests of the many public and private actors involved and knowledge of institutions. It is a major challenge to bring together such differing areas of knowledge in a single programme, but it will be necessary if we want to make a real contribution to the challenges of infrastructural development of the future."

What do the results mean for the future of Next Generation Infrastructures? Weijnen: "The quality hallmark given to us by the review committee places us more firmly on the map. It presents opportunities for attracting new funding. It is a shame, however, that it comes at a time when the economic climate is against us. For the time being, the synthesis challenge features prominently on our research agenda. And, of course, we continue to renew the content of the programme. Themes such as 'intelligent networks' and 'sustainable infrastructures' are rapidly growing in importance. We also aim to extend our 'modelling, simulation & gaming' platform and invest in the academic foundations of 'strategic asset management'. With the historians in Eindhoven, who also achieved a great external assessment score, we plan to investigate the possibilities of establishing a graduate school for infrastructural system research. In the coming years, we also plan to focus on strengthening our network of knowledge partners and knowledge users in Europe. There is plenty of work still to be done."

Ernst ten Heuvelhof



## Next Generation Infrastructures

### Smart Grids and Electric Driving

**By: Remco Verzijlbergh, PhD candidate in the Energy & Industry section**

The electricity sector is in transition. The changes are characterised by more fluctuating renewable energy sources, higher energy consumption (ironically, energy conservation often goes hand-in-hand with an increase in the use of electricity, as in the example of a gas-fired central heating boiler being replaced by a heat pump or a petrol-driven car by an electric one) and more local, small-scale generation.

The business-as-usual scenario would call for the construction of large numbers of new power stations and the installation of new cables in order to meet the additional demand and plug the gap in periods when there is no wind power or solar energy. The more innovative Smart Grid concept attempts to prevent these extra investments by taking a smart approach to adapting the demand for electricity to match supply. One essential condition for a successful Smart Grid is the use of 'controllable' equipment so that the demand for electricity can actually be adapted. And here lies the reason why the electric car is a key element in the Smart Grid: it is the ideal controllable appliance. Electric cars require a lot of energy and are capable of remaining 'online' virtually all the time and are possible in great numbers, distributed across the whole of the Netherlands. This makes them ideal for influencing the demand for electricity where necessary.

The research at the Energy & Industry section primarily focuses on the optimum exploitation of this flexibility of electric cars in order to facilitate the integration of renewable energy sources. This results in a dual benefit since electric cars and Smart Grids can be used to make both the transport and the electricity sector more sustainable.

### Maasvlakte 2

**By: Dr Rob Stikkelman, Director, Centre for Port Innovation and Regional Development, TU Delft**

What are you worth as a NGInfra research programme if you are not involved in the country's most appealing infrastructural project: the development of Maasvlakte 2 (MV2)? This is why, since 1 September 2010, we have been working in alliance with the Rotterdam Port Authority on the programme 'Next Generation Port Infra, powered by Maasvlakte 2'. The aim is to enable the application of existing NGInfra knowledge in the development, realisation and organisation of MV2. The initiative has been received very enthusiastically. The first interesting projects have already been launched, including 'Simulation of cluster developments in MV2'. The aim of the project is to create a simulation tool for employees that can show the effect of scenarios and decisions by the Rotterdam Port Authority on the potential development of industrial clusters and infrastructures in MV2. Important performance indicators include financial feasibility, sustainability and innovative character. Within the NGInfra programme, there has been a great deal of research into the structure of and behaviour within industrial infrastructures. Agent-Based Modelling (ABM) is used to understand how structures develop from the bottom-up based on the behaviour of individual companies. This technique is extremely useful for studying the development of complex systems but has only been applied in practice to a limited extent. This is something we intend to change.

The greatest challenge involved in the partnership is to synthesise the knowledge and experience from the researchers' and users' environment relating to clusters and infrastructures. The knowledge within NGInfra can make an extremely valuable contribution to increasing the understanding of Rotterdam Port Authority. In return the expertise of Rotterdam Port Authority can prove very useful in establishing infrastructural research that is firmly anchored in practice.

# License to operate



Jeroen van den Hoven and Peter Kroes

**As a 'licence to operate': this is how Peter Kroes, Jeroen van den Hoven and Maarten Franssen see the excellent assessment of their research programme Philosophy of Technology, Design and Values. In the programme, around thirty TPM scientists are taking a primarily philosophical look at how technology develops and the moral impact that it has. "Our focus is not on the strictly instrumental functionality of things, but on other value areas."**

Jeroen van den Hoven has no hesitation in presenting a concrete example: the smart electricity meter. "It is a piece of software to improve the management of the flows and peaks in the electricity grid. It is a superb innovation, on which major commercial players have collaborated hard. It has been carefully considered over a long period and fully developed. But when the first meters were installed in the homes of consumers two years ago, the Upper House of the Dutch Parliament outlawed the use of the smart meter for privacy reasons. The value of privacy should have been considered at a much earlier stage in the schedule of requirements. If that had happened, this problem could probably have been avoided."

This example also provides some illustration of how the impact of new technologies on our society is seen. Much philosophical reflection on the subject dates back a long way, but it looks back at the time when the technology

Maarten Franssen



was already there and fully developed. It also often adopts an approach that is critical of culture. "The approach we adopt is more productive", say Kroes and Franssen. "We take a critical look at how technology comes into being. How is it possible to design and develop technology in such a way that any problems are accounted for at an early stage? Prevention is

better than cure. If you include improvements early enough in the development process, you do not need to devise complex scenarios to solve the problems that arise."

The review committee confirmed the reputation of the TPM philosophy section, now considered as the place to be for this type of research. In 2005, Kroes et al. achieved the maximum score in the national external philosophy inspections. "It is good for your name and your reputation. Knowledge always comes before reputation", opines Van den Hoven. "You always need credit. Literally of course, but we also need support in a figurative sense for the plans that we want to develop. For TU Delft, the quality of research is becoming increasingly important. This positive result of the assessment is therefore a useful achievement. We have scored well for many years, both in terms of monodisciplinary and multidisciplinary research in areas of high relevance for policy."

In the coming years, the work will be developed further along two main research lines. The first of these is value-sensitive design. "How do you make the different value aspects of new technology explicit and how do you ensure that they are included in the design process? We aim to be the world leaders in this area within five years", says Franssen. The other important research area that the philosophy group aims to expand in the coming years is that of socio-technical systems. "Our entire faculty revolves around the role of these systems. How do we conceptualise and model such systems? This involves becoming even more firmly embedded within TPM. As philosophers, we are not and cannot remain isolated. The inspection report indicates that there are possibilities for more collaboration within the faculty in these areas. That is something we are working hard to achieve."

## Philosophy of Technology, Design, and Values



### Moral responsibility in research networks

**By: Dr Ibo van de Poel, Associate Professor, Philosophy section and Director of the 3TU. Centre for Ethics and Technology**

In the project 'moral responsibility in research networks' philosophers from TU Delft and TU Eindhoven have conducted joint research into the sharing of responsibility in non-hierarchical research networks. These types of networks face a particular problem because of the large numbers of people involved: everyone looks at each other when it comes to taking responsibility for the possible social consequences of the new technology. The researchers investigated how and why the problem of many people being involved actually occurs and developed a range of different solutions to the problem.

Firstly, they propose that responsibility should not only be understood in terms of retrospective blame, but also as a virtue or obligation beforehand. The parties in the research network should take active prior responsibility themselves for the consequences of the technologies that they are jointly developing.

Secondly, the researchers have developed a procedure that can help to jointly achieve an honest and effective distribution of responsibilities in a research network. This procedure has been successfully applied to a network in which new wireless technology was developed for use in healthcare.

Thirdly, the researchers used formal models of responsibility and organisations to investigate the relationship between the sharing of responsibility and organisational structures. In the long term, this can lead to proposals for changes to organisational structures which will make the problem of the involvement of multiple people less likely to occur.

### Nuclear waste

**By: Dr Behnam Taebi, Assistant Professor in Philosophy of Technology**

The debate about nuclear energy generally comes down to whether one is for or against. Even in the Netherlands, the cabinet faces an impending decision on the construction of one or two new power plants and this is causing a great deal of controversy in society at large. But before we can answer the question about its desirability, we first need to properly identify exactly what nuclear energy is. After all, various different production methods entail different choices for current and future generations.

In the production of nuclear energy (but also energy using coal, oil and gas) there are two important factors at play. These are 1) the energy is sourced from non-renewable raw materials and 2) waste produced during energy production creates potential future hazards. These aspects create a problem of

accountability between current and future generations; this also involves moral responsibilities.

In the technological choices we make, we must continually ask ourselves whether they are justified both for the current and future generations. In this kind of analysis, we need to answer fundamental questions about our relationship with those that succeed us. But any effective ethical analysis also needs to be well informed about the current state of technology.

This means that before we answer the question of what may be considered to be morally-justified action, we first need to understand what is technically possible. The progress of nuclear technology is creating much more complicated moral dilemmas for nuclear energy than was once thought.

# Space to explore new areas

**The research programme led by Wil Thissen is not one with clearly-defined parameters or structure. Multi-Actor Systems (MAS) covers various different departments and sections and is also deeply interwoven with the Next Generation Infrastructures programme. "The review committee could have asked critical questions about the wide variety and the relationship between our different research themes. There are six in total. Isn't that too many isolated components? It is a question we have also asked ourselves", says Thissen. But instead of that, MAS was rated highly for the dynamism and content of the programme.**

Multi-Actor Systems is the central meeting point for views from a range of different academic fields, including policy, public administration, applied operations research and system analysis. The programme aims to make a fundamental contribution to solving complex problems relating to decision-making and management in multi-actor systems. Issues tackled include infrastructure, transport and energy supplies in the future, or the consequences of climate change, for example.

The most important characteristics of the MAS programme are its variety, flexibility and the space that the TPM researchers get to take on new issues. Thissen: "We deliberately adopt both a narrow approach - exploring subsidiary niches or subsidiary

theories in order to gain world recognition - and a broader one. We encourage the sections to seek each other out and get to know each other. A key condition for the success of this approach is that the staff across all the sections understand each other's expertise and involve each other when tackling new subjects. Researchers are also permitted to experiment with complicated problems that may only deliver useful results in a few years' time. The review committee was full of praise for this approach. After all, no one knows what the most important topics will be in five years' time."

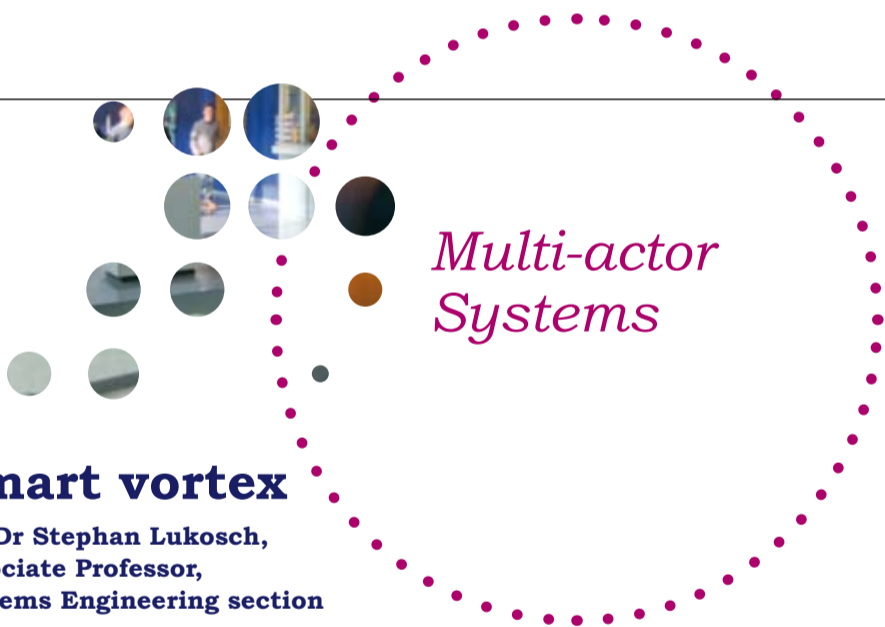
A topical theme at the moment is the development of long-term strategies in the face of major uncertainties. "Around five years ago, a new cluster was established for this in our Policy Analysis section. This subject is now really starting to take off. It is becoming involved in € tackle the complexity and major fundamental uncertainties involved in many current issues, such as adapting to climate change, energy transitions and investment in infrastructure. In this, we look to find general overriding principles: which of the many potential strategies best suit the different types of uncertainties? Another key area of focus is the development of tools to generate increasing numbers of future scenarios and then to distil the essential knowledge from the large amount of data generated.

This is linked to the theme of Serious Games and Simulations that has developed rapidly in recent years. Thissen also mentions the new ideas in Collaboration Engineering, focusing on the development of new working methods and tools in order to support cooperation between different parties. "The review committee values these subjects and this dynamism and so we

Wil Thissen



can continue to pursue our programme in full confidence. The only point of criticism was that we should do more to ensure that the basic knowledge and experience is recorded in international literature and textbooks. We have achieved that to a certain extent, but there is always room for improvement, of course. For that, we need sufficient senior researchers with an appropriate overview and the time required. They are currently overloaded with teaching, project management, acquisition and other business. That is one of the ongoing dilemmas we face."



## Smart vortex

**By: Dr Stephan Lukosch, Associate Professor, Systems Engineering section**

Since October 2010, the Systems Engineering section has been participating in SMART VORTEX. This project is funded by the European Commission as part of the Seventh Framework Programme. Its aim is to provide a technological infrastructure for the intelligent management and analysis of extremely large data streams so that they:

- achieve cooperation and decision-making that focus on objectives, for all actors in the entire life-cycle of the product;
- can promote innovation in the area of joint institutions across several organisations, and
- can expand the value chains, based on knowledge.

Within the project, the System Engineering section is focusing on improving cooperation and decision-making processes and the technical support involved. It is also providing support to the existing research into efficient

communal design and engineering for multi-actor systems within the section. Stephan Lukosch is responsible for the project. The academics involved in the project are Gwendolyn Kolfschoten, Jordan Janeiro, Selin Ebeci, Stefan Knoll, Martijn Warnier, Mamadou Seck, Alexander Verbraeck and Frances Brazier.

SMART VORTEX brings together 14 different European partners. The major industrial partners are Volvo Construction, AB Sandvik Coromant, Hägglunds Drives and Philips Consumer Lifestyle. The major academic partners are FernUniversität in Hagen, Technical University Darmstadt, Luleå University of Technology, Uppsala University and SAPIENZA - Università di Roma.

The project is being funded over a four-year period. It has a total budget of more than € 10 million, of which the European Commission is providing almost € 8 million. The Systems Engineering section receives € 740,000 of this budget, making it one of the key partners.

## Overcoming System-level Transitional Inertia: Accelerating the Dutch Energy Transition

**By: Dr Erik Pruyt, Assistant Professor, Policy Analysis section**

This NWO project was applied for and is supervised by Wil Thissen and Erik Pruyt from Policy Analysis, Igor Mayer from Policy, Organisation, Law and Gaming (POLG) and Matthijs Hischemöller from VU University Amsterdam. It focuses on the causes of inertia in energy transitions (more specifically in the built-up environment) and on innovative control mechanisms to combat this inertia. To achieve this, three researchers are using and combining a range of different approaches and methods at different levels:

Gönenç Yücel (post-doc, Policy Analysis) creates System Dynamics and Agent-based simulation models and uses these to conduct research into (i) the (feedback) mechanisms built into the system, (ii) the way in which mechanisms and factors delay or counteract necessary changes at system level and (iii) the possible long-term system effects of innovative control mechanisms.

Iman Mohammed (PhD, Policy Analysis and POLG) transforms this and other simulation

models into various types of game simulations for specific purposes and actors: from single-actor flight-simulators to investigate the behaviour of individuals under different system conditions and control mechanisms to multi-actor serious games to enable stakeholders/policymakers to experience system dynamics and inertia.

Gabriella Doci (PhD, VU) is using practical pilots at actor level to investigate whether these innovative control mechanisms (such as Corporate Social Responsibility) actually work in practice.

These different approaches complement each other very effectively. Iman is using simulation models and actors from the other projects in order to test hypotheses. In turn, Iman's results enable Gönenç to improve and validate his simulation models. Finally, the games and system analyses permit Gabriella's stakeholders/policymakers to understand the system effects of control mechanisms and decisions and experience them virtually.

# Lots of interesting business activity

**"The most valuable thing about the external inspection is that it forces you to reflect on what you are doing and what your plans are for the years to come. The programme always has to be in order. You need to know your strengths, but also your weaknesses in order to improve them. For example, it is important to cut out the old wood." With their Innovation Systems research programme, Cees van Beers and Alfred Kleinknecht were fully prepared.**

**The only additional work they needed to do when the review committee announced its impending arrival, was to put together a PowerPoint presentation, so to speak.**



Cees van Beers

It involved the simple principles of an extremely wide-ranging research programme. Innovation Systems focuses on the powers that drive or impede the innovation process. What makes one technological innovation a success and another a failure? Why does one (European) region, company or organisation (hospital, police force, home care, etc.) perform better than another? With this kind of research, TPM scores outstanding results, also in the judgement of the review committee. The creative collection of data also reveals developments that larger organisations like Statistics Netherlands (CBS) and Eurostat have overlooked, which policymakers in The Hague and Brussels can then use to develop policy. For example, when it comes to knowledge valorisation, to name just one subject.

Kleinknecht: "In the public debate, it is often claimed that there is insufficient transfer of academic scientific knowledge into practice in our country, whereas the United States performs well in this area. We have succeeded in demonstrating that within a 35 km radius around our Universities and Universities of Applied Sciences, there is a solid accumulation of innovative activity to be found. We counted around four hundred innovators. These are not people simply playing at innovation, but entrepreneurs who actually launch new products onto the market. Because these businesses are often small in scale, they are overlooked by the CBS and the Ministry of Economic Affairs is virtually unaware of their existence. The impact of universities and other educational institutions on innovative business in their geographical surroundings is significantly greater than that of the research labs at major companies."

An interesting question that came from the review committee was why TPM conducts research on entrepreneurship and the commercialisation of knowledge at company level rather than linking it together at macro-level, also for the benefit of policymakers. Van Beers:

Alfred Kleinknecht



"It is a deliberate choice, because we have to operate within a specific policy framework in the faculty and not replicate the work already being done in Rotterdam. But on the other hand, the fact that the review committee asked this question does provide food for thought. It is also linked to our desire to move more in the direction of the public sector. We have primarily focused on the private sector in recent years. And: we may also be overly modest. The committee feels that we should publicise our knowledge more effectively."

Innovation Systems was rated highly for its publications in high-profile journals. However, the number of publications is slightly lower than the TPM average. Kleinknecht: "We prefer not to publish just for the sake of it. It is more important to score higher than average for our subject area in the citation analysis. A total of 34% of our publications are in the top 5% of the world's most cited articles. We are very proud of that."

## Innovation Systems

### Information Technology (IT) and Firm Performance: The Role of Innovation?

By: *Ir. Fardad Zand*

IT Business Value (ITBV) focuses its research on three core issues that are of crucial importance for business managers, technology managers and policymakers: 1) what are the tangible and intangible influences of IT investments at the company, sector and national level? (2) how, and by means of what mechanisms does IT influence company results, sector efficiency and national productivity? (3) why do some companies, sectors and countries clearly benefit from their IT investments while others with a similar level of investment do not?

A good example of an ITBV project is a study, conducted by Fardad Zand and Cees van Beers, on the role played by innovation in the value-forming process of IT investments at the company level. A new theoretical framework has been developed for this and various panels have been established for the Netherlands and 29 other European countries.

The most important conclusions are: "IT is an important asset for companies in their efforts to gain and maintain a competitive advantage, but perhaps much more important is the way in which IT is used and for what purpose. This is the factor that makes the difference between the forerunners and role models in the field of IT and the stragglers who have made some amazing blunders."

This research will be continued in the near future and will analyse how information technology systems can be used effectively in order to encourage the sharing of knowledge by means of internal knowledge markets within companies. A similar question that occupies ITBV is how digital options made possible by IT (such as virtual currencies) can be used to encourage employees to create, modify, distribute and reuse information sustainably.

### Determinants of Innovative Behaviour

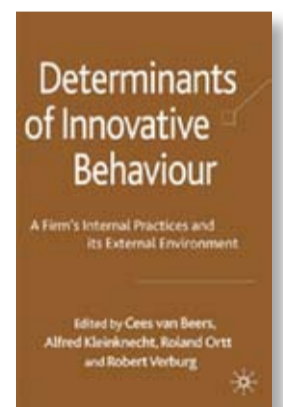
By: *Dr Robert M. Verburg, Associate Professor, TSE Section*

An increasing number of companies strive to achieve innovation and more and more work can be characterised as knowledge work. Overall, it is the specialists rather than the generalists who come out on top and the added value that employees contribute to the final product is now extremely high. In the past, entrepreneurs controlled important capital goods but nowadays they are increasingly dependent on the knowledge factor, which does not generally take the form of a machine in a factory but actually resides in people's heads. Our research focuses on finding answers to the question of how companies can recruit and direct the right people in order to maximise performance and contribute towards innovation. These insights form the basis for the teaching in our Master's programme, Management of Technology (MOT).

Traditional production processes are easier to manage than interpersonal processes such as the exchange and development of knowledge. Providing support for these kinds of processes presents a major challenge for management. Our research shows that more innovative organisations have a strong focus on informal working methods and the sharing of knowledge.

Traditional management focuses too strongly on issues such as budgeting and control, whereas modern-day professionals actually need their initiative, creativity and passion to be facilitated. Of course, there is nothing wrong with a certain level of monitoring and control. In our study of maintenance mechanics working on aircrafts, rigorous controls do in fact appear to be much more effective than a management philosophy that is based on creativity and improvisation. Today's technology management is complicated and there is a great need for new insights since tried-and-tested forms of management and organisation cannot meet the challenges they face in the modern world.

*Do you want to find out more? Read **Determinants of Innovative Behaviour: A Firm's Internal Practices and its External Environment**, geschreven door Cees van Beers, Alfred Kleinknecht, Roland Ortt en Robert Verburg.*



# Back to business

**For someone who spends his days dealing with crises and disasters, a visit by the visitation committee can hardly be described as nerve-wracking. Ben Ale is down to earth in his assessment: "I believe it is only normal for people to want to see what we have achieved with our programme, if only because so much money is spent on it. It is also great to receive confirmation of the fact that we are on the right track, but that is about as far as it goes."**

The Risk & Design programme Leader is happy to return to his everyday activities: disaster and crisis management at a local and global level. From the riots in Hoek van Holland and the recent fire in Moerdijk, to the blow-out and explosion of the BP Deep Horizon oil platform in the Gulf of Mexico almost a year ago now (12 April). All of them ultimately raise the same questions: what lessons can we learn and what can technology do to prevent or reduce human suffering and social and material damage in the future?

Part of the answer - and indeed one of the key areas of focus for TPM research - can be found in the fact that decisions are increasingly being made at lower levels within organisations. Ale: "How is it possible for the boss of a drilling platform to cause damage in excess of €40 billion, bringing BP to the brink of bankruptcy? The fact that there were also eleven deaths has been almost forgotten and yet BP has a reputation for being an extremely safe company. And what could have brought four policemen in Hoek van Holland to the point where they felt it necessary to shoot and use up all their ammunition? Most of the police force never even use their guns and if they do they tend to fire only one or two shots."

In recent years, Ale has made major progress in the development of new research instruments. They are mathematical techniques used to relate cause and effect to each other, increasing our understanding of the relationship between different levels of decision-making and explaining how decisions shift from one level to another. Research is also being conducted into the perception of risk and crises and the raising of alarms, as in the case of the fire in Moerdijk. Ale: "Why did this fire achieve national emergency status, when the damage it caused was comparable to the fire in our Faculty of Architecture? Why did people refuse to believe that there was nothing fishy going on?"

"Now everyone is calling for increased and improved inspections. Yet these are the same people who just six months ago published a report calling for savings of €35 million on fire service inspections. This trend is at odds with what we as scientists believe should happen. To me, as a selfish researcher, a good disaster has its uses, even if our work revolves around trying to prevent them from happening."

The review committee praised his team for its excellent performance. Does Ale not feel any sense of pride? "The most important point and the main area of criticism was the comment that the average age of incumbent staff is on the high side, which may present a risk for the continuity of our research. I do wonder whether this is really within the review committee's remit. But they are long gone now, so I can't tackle them about it."

## Security at airfields

**By: Dr Coen van Gulijk, Assistant Professor, Safety Science section**

Human factors are an important area of research in the issue of safety. In general, protection against accidents is the key issue, in other words, situations that cause unintended damage. The BEMOSA project investigates the human factor in protection against situations that lead to deliberate damage: security at airports. The conduct of staff and visitors to airfields is examined by means of ethnographic research in order to develop a behavioural model for security (BEhavioral MOdel for Security at Airports: BEMOSA).

The focus is on the decision-making process of security personnel. Especially in crisis situations, many decisions are group decisions. The model will therefore be a sociological decision-making model for security in crisis situations. It will be used to develop a training programme to enable faster and more effective group decisions with the aim of achieving a more efficient approach to security and crisis. This is the first time that research into the human factors of security staff has been conducted on this scale within Europe.

BEMOSA is an EU research project in the Seventh Framework Programme. The academic team is made up of safety and security experts and sociologists, coordinated by the Technion University (Haifa). The other academic partners are TU Delft, the Unimore Universiteit (Italy) and the University of Zilina (Slovenia). In addition, various European companies and the Brno airfield are involved in the project. In view of the pan-European approach, airfields of different sizes are being studied, including Rome, Amsterdam, Athens and Brno.

TPM is providing expertise and research capacity in the form of three scientists: Coen van Gulijk, Hinke Andriessen and Ben Ale. In addition to designing and conducting ethnographic research at Schiphol, Brno, Rome and Stockholm, they are also working on the design of the behavioural model and the development of training programmes. The initial results have been warmly welcomed by the airfields and the European Commission.

See also <http://bemosa.technion.ac.il>

## Shell project

**By: Prof. Ben Ale, Professor of Safety Science and Disaster Abatement, TU Delft**

The recent disaster in the Gulf of Mexico brought to light a number of major problems encountered in safety management in all high-risk sectors. Although these kinds of incidents are extremely unlikely to happen, they have enormous consequences when they do. The fact that they continue to happen is scientific proof that the current theories and practices relating to high-risk activities such as oil and gas exploration, refinery and commercial aviation are insufficient.

Recent plans suggest that the causes of incidents should be considered to be both non-linear and non-deterministic.

Current probability calculations in risk analysis programmes are based on fault and error trees. In these analyses, defining mutual interrelationships of a more complex nature, especially those caused by human behaviour, is only possible by means of estimates. However, it is no longer acceptable to ignore or to simplify the interaction between what are often incommensurable elements within these types of systems.

TU Delft Safety Science has a new approach to probability models, Bayesian Belief Networks, which have been successfully applied in civil aviation, and it is developing a solid framework that can be applied in other high-risk industries. It takes a different perspective to the uncertainty within complex systems in which the separate probabilities become extremely small, but which have far-reaching consequences. In addition, risk analyses between the highest and lowest levels of organisations appear to be at odds with each other. There is a clear need for a shared understanding between the executive management and the people who carry out the work.

This project, fully funded by SHELL, aims to provide a sufficiently transparent basis for carefully-considered commercial risk analysis.



Ben Ale

TPM-Quarterly is a publication of the Faculty of Technology, Policy and Management at TU Delft.

**Text & editing** - Marketing & Communication TPM, De Taalfax, Francissen Communicatie, Haverkamp & Bergers **Design & lay-out** - Heike Slingerland BNO, Vlaardingen **Photography** - Daniëlle van der Schans, Jacqueline de Haas, Guus Schoonewille **Printing** - Schefferdrukkerij B.V., Dordrecht **Translations** - UvA Talen, Amsterdam **Print run** - Dutch version 2000

Please contact [news-tbm@tudelft.nl](mailto:news-tbm@tudelft.nl) if you have ideas for articles for TPM Quarterly.

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# Professor profile



## NAME

**Prof. Frances M.T. Brazier**

## POSITION

**I am the Systems Engineering section manager in the Multi-Actor Systems department and the title of my chair is Engineering Systems Foundations.**

## Tell us about your personal life

I was born in Toronto (1957), but have lived in the Netherlands since I was a teenager. I am married and have a son aged 12. We live in Ter Aar, with a beautiful view of the countryside. Every day when I'm not at work, I go walking; rambling through the countryside is something I really enjoy!

## What is your favourite hobby?

Apart from walking, I enjoy cookery and swimming and I like going to the sauna. We recently had our own sauna installed - it's wonderful! I also like to spend as much time as possible with my family. We like going on excursions; last year we even went to see the launch of the space shuttle in the States. This also includes seeing family and friends; I have some long-term friendships with people from all over the world and we regularly have people to stay from abroad.

## The high point of your career?

It is difficult to choose a single event as a highlight. Wonderful things happen on a daily basis. One special occasion was when I defended my thesis, and held my inaugural speech, ten years ago at the VU, entitled 'Agents on the Go: Next Generation Interactive Internet Systems'. When you realise that things are working and everything is falling into place, it's a fantastic experience. I am also looking forward to my second inaugural speech, on 14 October this year, in Delft, when I will talk on the subject of Participatory Systems.

## Your greatest challenge?

Our new Participatory Systems Initiative, and the challenge is the subject of large-scale distributed systems - technical, social, ecological systems. These are systems in which human agency and agency in the form of organisational and technological infrastructure are designed to be in balance with each other. The challenge of the Participatory Systems Initiative is to identify a new paradigm for the design of these dynamic adaptive network systems. The key issue here is to give people technical possibilities that enable them to take personal responsibility as participants in major complex dynamic systems. This research calls for cooperation across the different disciplines - as is customary here in the faculty - nationally and internationally, with experts in design and technology, but also with researchers from the social sciences, from law, design and art. One special aspect of this is my role in our faculty's cooperation with Eleanor Ostrom, the Nobel prize-winner for Economics in 2009. In the field of common pools, she is seeking to identify the limits of autonomy. We actually do the same here, at the interface between ecology, society and technology.

## What do you enjoy most about your work?

I worked for 28 years as professor of Intelligent Interactive Distributed Systems (IIDS) at the Faculty of Sciences at the VU in Amsterdam. In 2009, our whole group moved to TU Delft. What I find particularly gratifying is that I now have the opportunity to develop my research into the self-management of complex autonomous systems in the interdisciplinary environment offered by TPM. I strongly believe in bringing together different fields of knowledge and in the synergy that that delivers. That is reflected in my academic background in Mathematics/Computer Studies, Cognitive Psychology and Artificial Intelligence. I am also the vice-chair of the National Network of Women Professors. I believe that there is a lot of room for improvement with regard to the position of women within the academic world. Finally, I also enjoy being a pioneer. For example, I am one of the founders of NLnet, the very first internet service provider in the Netherlands and was the director of research of the Stichting NLnet for ten years. I am now a member of the board of Stichting NLnet Labs.

## Why Delft?

At general universities, the grounding of scientific research in practice is often missing. Here in Delft, the practical application is always at the forefront. The interdisciplinary approach is also one that I was almost born into. The same is true of the sustainability agenda of TU Delft, which deals with major issues in society such as energy and health. These affect everyone and I am fascinated by the question of how to organise these kinds of large systems. What are the systems capable of themselves, and how do you create interaction? And, last but not least, I find the atmosphere here in Delft highly inspirational.

## Your best characteristic?

Building bridges. I always try to understand what people do and why they do it. If you understand what drives people and why, it is possible to make progress.

## Your worst characteristic?

Patience, but not in my dealings with other people, but mainly with myself. I really want things to happen. For example, I would like to see a culture shift in the academic world, in favour of women. This transformation cannot happen fast enough for me! I have this impatience in many areas. I always want much more than is possible at any given time. It all started when I was six years old; even then I wanted all the things that were not possible at my age.

## What subject do you think should be high on the political agenda?

Trust. Ensure that people regain trust and confidence in government and in the systems that you develop. It is important to incorporate transparency, to include autonomy and responsibility in the design; it helps to increase trust. For example on the issue of personal data: how can you guarantee integrity and privacy, how can you ensure that data is removed from the system forever when it needs to be?

## Your source of inspiration?

Not a particular person or book, but the idea that cooperation between the different disciplines can lead to inspiration. I also always follow my intuition, even if that may seem rather strange for a real scientist like me.

## Your life philosophy?

There is still so much to discover!

## TPM's educational programmes

■ BSc Systems Engineering, Policy Analysis and Management ('Technische Bestuurskunde', TB) ■ MSc Systems Engineering, Policy Analysis and Management (SEPAM) ■ MSc Management of Technology (MoT) ■ MSc Engineering and Policy Analysis (EPA) ■ MSc Transport, Infrastructure and Logistics (TIL) (in cooperation with the Faculty of Civil Engineering & Geosciences and the Faculty of Mechanical, Maritime and Materials Engineering) ■ MSc Information Architecture (IA) (in cooperation with the Faculty of Electrical Engineering, Applied Mathematics and Computer Science) ■ MSc Geomatics (in cooperation with the Faculty of Civil Engineering & Geosciences and the Faculty of Aerospace Engineering)

Did you thoroughly read the available information and are you considering enrollment in a TPM-programme? Are you not sure your educational background is sufficient? Then please contact one of our study advisors: Drs. Marja Brand ✉ (m.j.c.c.brand@tudelft.nl), Ir. Jeannette Blokland ✉ (a.h.blokland@tudelft.nl) or Drs. Danielle Rietdijk ✉ (d.rietdijk@tudelft.nl).